Postoperative Sensitivity in Class I Composite Resin Restorations in vivo

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Purpose: This study evaluated the postoperative sensitivity of posterior Class I composite resin restorations, restored with a self-etching or a total-etch one-bottle adhesive system.

Materials and Methods: One hundred four restorations were replaced by one clinician in 52 patients. Each patient received two restorations. After cavity preparations were completed under rubber-dam isolation, they were restored using Clearfil SE Bond or Single Bond and a resin-based restorative material (Filtek Z250). Sensitivity was evaluated at 0 and 7 days and 6 months using cold stimuli, and recorded using a visual analogue scale. If sensitivity was experienced on day 7, patients were also contacted on days 14 and 30 to assess the degree of sensitivity. The scores were analyzed as nonparametric data by means of the Friedman and Wilcoxon tests.

Results: No statistically significant differences in sensitivity were found between the two adhesives systems at days 0 and 7 or at 6 months. No spontaneous postoperative sensitivity was reported.

Conclusions: The adhesives systems used in this study showed no differences in postoperative sensitivity, and did not show spontaneous sensitivity after 6 months.

Keywords: postoperative sensitivity, adhesive system, composite resin.

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Manhart et al[12] observed that 60% of restorations are replacements. Many authors have given the following reasons for replacement: secondary caries, inadequate anatomical form, poor surface texture, restoration fracture (bulk or margin), tooth fracture, and overhanging margin.[7,11-13]

New resin-based bonding materials and composite systems are regularly introduced for use in the esthetic restoration of posterior cavities.[6,10-13,27] These materials have two main characteristics: they are tooth colored and they can bond to tooth structure.[10,11,27] The use of resin-based composite materials became more popular as studies reported good durability when they were placed in small cavities under ideal conditions.[10-12]

Adhesive bonding systems used to bond resin composites to dental tissue have developed rapidly over the past 30 years, beginning in the 1960s with the development of the first commercial products, followed by introduction of the acid-etch technique in clinical practice in the 1970s.[4,13,19] Since then, bonding systems have steadily become more refined and diversified. The current trend is to reduce the multistep adhesive process, so as to lessen the sensitivity to errors of inaccurate or incorrect operator handling.[21] Currently, many clinicians use one-bottle adhesive systems or self-etching/self-priming bonding systems.[21] Each type of adhesive bonding system has its advantages and limitations, but how these materials compare to each other in terms of pulp reaction is still uncertain.[13]

Long-term dental material bonding to dentin has been a contentious issue, and the results of in vitro testing do not reflect those found in vivo.[10,11,27] Although resin-based composite materials and adhesive technology have rapidly advanced, polymerizaton shrinkage and postoperative sensitivity still remain challenges to practitioners.[6,10,14,15,25,26] Clinical studies have also indicated that up to 30% of the studied populations have reported postoperative sensitivity following restoration with a posterior composite resin.[6,10,11,14,15,20,25-27]

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Table 1 Composition of the adhesive systems used in this study

Adhesive Systems	Composition	Procedures	Manufacturer
Single Bond (G1)	Conditioner: 35% phosphoric acid (pH 0.02) Adhesive: water, ethanol, bis-GMA, HEMA, UDMA, bisphenol A glycerolate, polyalkenoic acid copolymer, dimethacrylate, camphorquinone	Acid etching (15 s); rinse; dry with cotton pellet; apply adhesive (2 coats); gently air dry; light cure (10 s)	3M ESPE, St Paul, MN, USA
Clearfil SE Bond (G2)	SE-Primer: water, ethanol, MDP, HEMA, dimethacrylate hydrophilic, camphorquinone, N,N-diethanol p-toluidine (pH=2) SE-Bond: MDP, bis-GMA, HEMA, dimethacrylate hydrophobic, camphorquinone, N,N-diethanol p-toluidine, silanized colloidal silica	Apply primer (20 s); gently air dry; apply adhesive; gently air dry; light cure (10 s)	Kuraray, Osaka, Japan

Several theories have been proposed over the years to explain the transmission of pain. The first proposed that the dentinal tubule has a nerve running along the entire tubule length to the free surface. The second proposed that odontoblasts could serve as receptors. Brännstrom reintroduced Gysi's concept that dentin sensitivity may be due to the movement of tubule contents, the so-called hydrodynamic theory of sensitivity.[1-3,8,16-18,24]

Sensitivity can be related to preparation trauma and restoration leakage with the entry of bacteria.[13] Sensitivity may also result from polymerization shrinkage[6] and deformation of the restoration under occlusal stress, which transmits hydraulic pressure to the odontoblastic processes.[6,10,24]

For many years, acid etching of vital dentin has also been related to postoperative problems, such as tooth sensitivity and pulp inflammation.[25] This view has also been supported by the fact that various components of dentin bonding agents and restorative resin materials are directly toxic to cells. Dentin conditioning agents can also be harmful when the pH value is lower than 5.5 and when they approach or come into contact with pulp.[13,22,23,25] However, the absence of a protective layer was not the primary cause of postoperat ive sensitivity.[25,26] Several authors[13,25,26] have claimed that acid etchants and composites have no adverse effects on the pulp, and that such restorations do not require protective liners or bases, if the adhesives achieve good cavity sealing. This view is further extended to the use of dentin bonding materials, such as direct pulp capping agents.

Many authors observed that there tended to be less postoperative sensitivity with the self-etching/self-priming bonding systems that require no rinsing step, compared to total-etch bonding systems.[4,15] In spite of this, clinical studies on the longevity of Class I and II composite resin restorations combined with a total-etch technique showed that there was hardly any postoperative sensitivity.[14,15,20,27] Postoperative sensitivity generally diminishes in the first few weeks after restoration placement,[20] but sometimes it persists for a longer period of time[13,14] and may be a reason for replacing the restoration.

This study tests the hypothesis that the incidence of postoperative sensitivity in resin composites was equal when self-etching systems were compared to total-etch adhesive systems, if they were used according to the manufacturer's instructions.

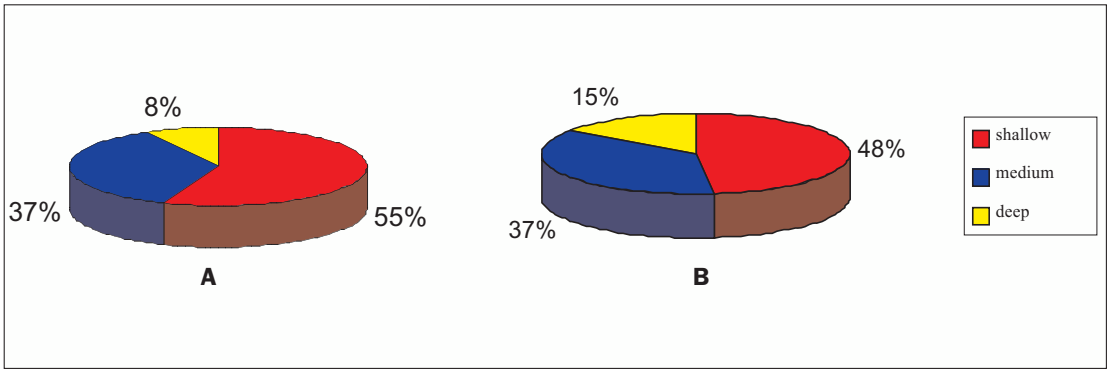
MATERIALS AND METHODS

One hundred four Class I restorations were included. The restorations were placed by one clinician in 52 patients ranging in age from 18 to 30 years. Each patient received two restorations with both treatments. Patients were informed about the study and signed a consent form approved by the local ethics committee.

Clinical criteria included patients with molar-supported permanent dentition, free of any edentulous spaces and occlusal interference of clinical significance, and two molars of antagonist quadrants requiring replacement of Class I amalgam restorations. Specific criteria included vital teeth and sound occlusal and proximal contact with adjacent teeth. Teeth with a previous history of sensitivity were excluded from the study. Patients taking analgesics that could alter their normal pain perception were not included in the study.

Patients were asked to rate the sensitivity perception experienced during cold stimulation by placing a mark on a visual analog scale (VAS) with units from 0 to 10 (where 0 = no pain and 10 = excruciating pain).[5,9] At baseline, all patients were tested for sensitivity of the selected tooth before treatment.

After cavity preparations and removal of amalgam restorations were completed, the depth of each cavity preparation was evaluated clinically and radiographically by interproximal (bitewing) radiographs: in 54 teeth, the cavity preparation was located in the inner one-third of dentin (shallow cavities), 38 were located in the middle



Figs 1a and b Diagramm shows depth of cavities restored with Single Bond (G1; 1A) or Clearfil SE Bond (G2; 1B).

Table 2 Postoperative sensitivity (VAS) by time and type of treatment

	T1 (baseline)			T2 (7 days)			T3 (6 months)		
	min	max	mean	min	max	mean	min	max	mean
Single Bond (G1)	0	3.7	0	0	4	0	0	1	0
Clearfil (G2)	0	3.9	0	0	5.1	0	0	2.5	0

Friedman and Wilcoxon tests showed no significant differences at $p < 0.05$.

third of dentin (medium cavities), and 12 were located in the outer third of dentin (deep cavities).

One hundred four molars were restored according to one of two protocols under rubber-dam isolation. Group 1 was treated with Single Bond and group 2 with Clearfil SE Bond according to manufacturer's instructions (for details, see Table 1).

The resin-based material (Filtek Z250, 3M/ESPE) was applied in increments of approximately 2 mm using the oblique technique. Each layer was then polymerized with a visible light-curing unit (Degulux, Degussa, Hanau, Germany). Appropriate occlusion contact points were restored. No base or cavity liners were used. All patients were seen by the clinician on postoperative day 7. On the 7th postoperative day, the restorations were finished under water cooling with fine and super-fine diamond points (KG Sorensen, Alphaville, São Paulo, Brazil) and polished with diamond-impregnated rubber points. Postoperative sensitivity was again evaluated by visual analog scale. On the same day, another restoration (restoration B) in the antagonist quadrant was replaced.

If patients experienced discomfort on day 7, they were also contacted on days 14 and 30 to assess sensitivity. All patients, including those with no positive sensitivity record on day 7, were instructed to report to the investigator if they experienced any sensitivity or other discomfort during the study.

All patients were examined at a 6-month recall examination of the restorations. Data were managed and analyzed using the Statistical Analysis System (SAS). Friedman and Wilcoxon tests were used to test for statistical significance ($p < 0.05$).

RESULTS

One hundred four restorations were carried out in 52 subjects. Each subject had two teeth restored with both treatments.

Figure 1 shows the distribution of the 104 total restorations placed by cavity depth for both bonding systems. Approximately 55% of the cavities in group 1 were shallow, followed by medium (37%) and deep (8%). In group 2, about 48% of the restorations were shallow, 37% were of a medium depth, and 15% were placed in deep cavities (Fig 1).

The postoperative sensitivity data were not normally distributed. Thus, to analyze the results in relation to the different times, the Friedman nonparametric analysis was used at a 5% level of significance. The Friedman nonparametric test (Table 2) showed that there was no statistically significant difference in the sensitivity level when the baseline (T1) was compared with the post-treatment times (T2 and T3) for the restorations made with Single Bond. There was also no statistically significant difference when the times T1, T2, and T3 were compared for the restorations done with Clearfil SE Bond. The Wilcoxon test, which compares the two types of treatment, also revealed no statistically significant difference ($p > 0.05$) (Table 2).

Table 3 shows the distribution of patients in terms of pain intensity at different time intervals. In the group treated with Single Bond (G1) 7 days after the procedure (T2), 37 (71.15%) patients did not experience postoperative sensitivity (value zero). Nine patients had sensitivity values higher than zero to 1. Three patients showed values of 1.1 to 2. Only one patient reported a higher value than two to 3, and two patients had values higher than 3.

Thirty-four patients in the group treated with Clearfil SE Bond (G2) reported no postoperative sensitivity at time 2. Thirteen showed sensitivity values higher than zero to 1.

Table 3 Distribution of patients in relation to sensitivity value at times T2 and T3

Sensitivity values/time	G1-T2	G2-T2	G1-T3	G2-T3
0	37	34	45	44
0.1 to 1	09	13	07	05
1.1 to 2	03	0	30	01
2.1 to 3	01	01	0	02
Higher than 3	02	01	0	0

G1: Single Bond; G2: Clearfil SE Bond.

Three patients had values of 1.1 to 2. One patient indicated a value between 2 and 3, and one had a value higher than 3. With regard to pain intensity in G1 at time T3 (6 months), 86.53% of the patients reported no postoperative sensitivity. The remainder (13.46%) of the patients showed sensitivity values higher than zero to 1. No patient presented values higher than 1. In Group 2 after 6 months, 44 patients indicated no postoperative sensitivity. For 5 patients, pain values between 0.1 to 1 were recorded. Only one patient showed a value between 1.1 and 2, while two indicated values between 2.1 and 3. None showed values higher than 3.

No spontaneous pain was detected in restorations placed with either category of adhesive. No sensitivity was present after day 14, which was also confirmed at the 6-month recall.

DISCUSSION

Elderton[7] reviewed the extent of restoration failures and pointed out that about one third of all amalgam restorations failed for one reason or another. Secondary caries was the main reason for replacement, followed by restoration fracture.[7,12,13] In the present study, the following were the main reasons for replacement: restoration fracture (38.47%), poor surface texture (37.5%), poor anatomical form (19.23%), and secondary caries (4.8%).

However, after a posterior composite resin restoration has been replaced, dentists often report postoperative sensitivity as a clinical problem. Clinical studies revealed the presence of such complaints in 0 to 30% of the studied populations.[6,10,11,14,15,20,25-27]

Studies have shown that age is an important factor, since in older patients, partial or complete obturation of tubules may occur, resulting in growth of the peritubular dentin.[10] The patients who participated in this study ranged from 18 to 30 years of age. This narrow range was contemplated for the purpose of standardization. Furthermore, the same patient received both treatments; thus, the patient was better able to assess sensitivity and standardization was improved.

Clinical studies[14,15,26] that evaluated postoperative sensitivity included criteria for the presence or absence of spontaneous pain, thermal sensitivity, and sensitivity to percussion. In this study, sensitivity was evaluated at 0 and 7 days and 6 months using cold stimuli, and recorded using a visual analogue scale, which is a widely used and reliable method of measuring sensitivity.[5,9]

To avoid postoperative sensitivity, the quality of the adhesive systems is important, including good composite adaptation to the cavity wall. Class I restorations have the highest C factor among preparations, since they present 6 surfaces, of which only one is free. The box-shaped configuration of the cavity may lead to considerable polymerization shrinkage stress and therefore to increased gap formation.[10,14] Polymerization shrinkage stress can be reduced by applying the composite resin incrementally[6,10,14] and by curing it indirectly through the cusps.[14] Opdam et al[14] also support the theory that an application in layers results in a better restoration. Because all the preparations of this study were Class I, the oblique incremental technique was selected.

The hydrodynamic theory of dentin sensitivity states that movement of tubule contents or tubule fluid in either direction causes dentin sensitivity. A corollary of this theory is that anything that can decrease dentinal fluid movement or dentin permeability should decrease dentin sensitivity.[1-3,8,16-18,24]

One of the major findings in this study was that there was no significant difference in postoperative sensitivity between SE (self-etching) adhesive systems and SB (one-bottle) systems. This may be due to the meticulous care taken to use these systems in accordance with the manufacturers' instructions.[20,21] The good sealing of dentin tubules is effective in decreasing dentin permeability, which, in turn, reduces postoperative sensitivity.[16,17,26] The use of one-bottle adhesive systems begins with the total acid etching of enamel and dentin with a phosphoric acid solution, followed by water rinsing. The subsequent air-drying step could be considered detrimental to adhesion,[21] if the adhesive is not used according to the manufacturers' instructions, because the demineralized dentin shrinks and thus the diffusion of resin into the spaces around collagen fibers is limited.[4,19] In contrast, when using self-etching adhesive systems, there is no rinsing step. Minerals that are solubilized during self-etching remain dissolved in the primer, so there is no loss of mass; hence, the fibers cannot collapse when the solvents are gently evaporated. In addition, the smear plugs are not removed with self-etching primers.[20,22,23,26] This can substantially reduce the potential for postoperative sensitivity that is caused by incomplete resin sealing of patent dentin tubules.[16,17,20,24,26]

Clinical studies[14,15] have not found any relation between the presence of a gap between the restoration and the dentin and tooth sensitivity. Nevertheless, the presence of such a gap at the cavity floor could be an explanation for the hypothesis that loading the teeth caused percolation of fluids in the tubules, resulting in sensitivity.[6] This indicates that good dentin tubule sealing is a factor in the prevention of postoperative sensitivity.[13,20,24,26]

In contrast with other in vivo studies,[25,26] the total-etch one-bottle adhesive systems did not yield high postoperative sensitivity values, since it is widely agreed that good dentin tubule sealing occurred because the agents were used meticulously. Furthermore, in previous studies, it was noted that older bonding systems were used, including multiple-bottle adhesives.[14,15] This demonstrates the superiority and development of current adhesive systems.

At 6 months, no spontaneous sensitivity was found and no statistically significant differences in sensitivity were found between the two adhesives systems, confirming good obturation of the tubules with both of the adhesive systems used in this study.

The cavities were grouped according to Unemori et al[25] by using interproximal radiography after cavity preparation. The radiographs were measured by means of a digital pachymeter and classified as shallow, medium, or deep if the floor of the cavity was in the external third, the middle third, or in the more internal third of the dentin, respectively. Although Unemori et al[25] referred to the fact that these were not strict guidelines for defining deep or shallow cavity preparations, we used the same classification as the one described in his work.[25,26]

In this clinical study, when over 104 composite restorations were grouped by cavity depth, there was no difference in the IPS when either of the adhesive systems were used. In shallow cavities, both the density and diameter of dentin tubules decrease as the enamel-dentin junction is approached.[24,26] Shallow cavities have the greatest dentin thickness remaining between the cavity floor and the pulp chamber.[24] Thick dentin offers more resistance to hydrodynamically-induced fluid flow than does thin dentin.[17,19,24] Although studies such as those of Unemori et al[26] showed greater sensitivity in medium and deep cavities, even with the use of bases, their results differ from those found in the present study, which emphasize that the correct use of the bonding system does not lead to postoperative sensitivity.[21]

The short-term postoperative sensitivity in this study was assessed about 7 days after the restorations were inserted. Another assessment was made about 6 months later, but further clinical studies are required to prove the biocompatibility of dentin bonding agents with pulpal soft tissue. Nevertheless, both adhesive systems tested in the present study were effective in overcoming short-term pulpal sensitivity, which was one of the major problems with early generation dentin bonding systems. This demonstrates the significant progress made in developing simpler, more effective dentin bonding agents.[26]

CONCLUSIONS

This study showed that postoperative sensitivity, as one of the major factors determining the clinical success of a composite resin restoration, is significantly influenced by the restorative technique used by the clinician. However, it also showed that special attention should be paid to using adhesive systems according to the manufacturer's instructions.

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Clinical relevance: There is no difference in postoperative sensitivity between Single Bond and Clearfil SE Bond after 6 months if they are used in accordance with the manufacturer's instructions.